

## PATENT COOPERATION TREATY

PCT

## NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner  
 US Department of Commerce  
 United States Patent and Trademark  
 Office, PCT  
 2011 South Clark Place Room  
 CP2/5C24  
 Arlington, VA 22202  
 ETATS-UNIS D'AMERIQUE  
 in its capacity as elected Office

Date of mailing (day/month/year) 12 March 2001 (12.03.01)	
International application No. PCT/NO00/00215	Applicant's or agent's file reference 102834JH
International filing date (day/month/year) 22 June 2000 (22.06.00)	Priority date (day/month/year) 23 June 1999 (23.06.99)
Applicant PERRET, Graham et al	

1. The designated Office is hereby notified of its election made:

☒ in the demand filed with the International Preliminary Examining Authority on:  
15 January 2001 (15.01.01)

☐ in a notice effecting later election filed with the International Bureau on:

2. The election ☒ was

☐ was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

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19993116                      23 June 1999 (23.06.1999)    **NO**

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(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

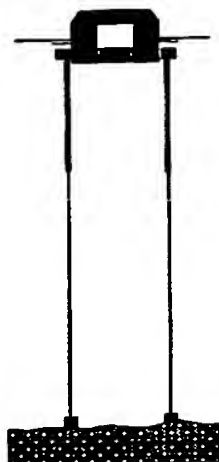
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**Published:**

- *With international search report.*
- *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

(54) Title: **DEEP WATER TLP TETHER SYSTEM**



TLP with tethers

(57) Abstract: The invention proposes to increase the diameter of the top sections (2) of the tethers on tension leg platforms (TLP) (4) to make top sections (1) positively buoyant. This buoyancy can be designed to compensate for the weight of the lower sections (2) to make the total buoyancy of the tether closer to neutral. The selection process for each section is driven by requirements for buoyancy, stiffness and external pressure resistance.



**WO 00/78601 A1**

## **Deep water TLP Tether System**

This invention relates to the art of offshore structures and, more particularly, to tension leg platforms (TLP) for exploitation of deep sea hydrocarbon reserves .

5 Mooring elements, or tethers on tension leg platforms are anchored to the seabed. They usually consist of steel pipes and are kept in tension by the buoyancy of the platform.

10 With the gradual depletion of onshore and shallow subsea subterranean hydrocarbon reservoirs, the search for additional petroleum reserves is being extended into deeper and deeper waters. As such deeper reservoirs are discovered, increasingly complex and sophisticated production systems are being developed. It is projected that soon, offshore exploration and production facilities will be required for probing depths of 1500m or more.

15

One way of reaching these depths is by using Tension Leg Platforms. A TLP comprises a semi-submersible-type floating platform anchored to foundations on the sea bed through members or mooring lines called tension legs or tethers. The tension legs are maintained in tension at all times by ensuring that the buoy-  
20 ancy of the TLP exceeds its operating weight under all environmental conditions. The TLP is compliantly restrained by this mooring system against lateral offset allowing limited surge, sway and yaw. Motions in the vertical direction of heave, pitch and roll are stiffly restrained by the tension legs.

25 External flotation systems can be attached to the legs but their long-term reliability is questionable. Furthermore, added buoyancy of this type causes an increase in the hydrodynamic forces on the leg structure.

TLPs' based on today's technology are considered competitive down to 1,000-  
30 1,500m. Beyond this depth, the tether system becomes increasingly heavy, requiring an increased platform size to carry the tether weight. This results in a larger platform, which has a significant impact on the overall cost.

For a TLP at 3,000m, a conventional tether system (one thickness, one diameter) represent a weight almost equal the payload. In previous designs, it has been proposed to reduce the wall thickness at the top to reduce the weight penalty. A solution to avoid these disadvantages related to the TLP, is to modify the tether system to reduce the need for increased hull size. The industry has devoted a considerable effort to develop tether systems based on various designs. Filling tether pipes with low density material, pressurising the interior to increase the hydrostatic capacity and replacing the steel tether pipes by composites are examples of these efforts.

Another solution can be found in NO 1997 3044, showing a design used for depths down to 700 m, built by pipe sections with a diameter between 0,5 to 1,2 m. The overall buoyancy of the tension leg is meant to be more or less neutral. This is achieved by adding an additional floating body at the top of the pipe.

NO 1997 3045 shows a welding connection on a tension leg. The publication shows two pipes of different diameter and wall thickness' welded together.

The object of the present invention is to overcome the above mentioned deficiencies and to design tethers for TLP's that reduces the necessary added payload on the platform due to the tether weight. This object is achieved by a TLP as defined in the appending claims.

The invention relates to a tether system for TLP's, with tethers having upper and lower pipe sections, the tethers having a reduction of the diameter towards the seabed.

The invention is a concept for modifying today's technology for use in ultra deep waters. By introducing reductions in the tether diameter, the lower sections of the tether towards the sea bed will normally be negatively buoyant because of the considerable wall thickness necessary to withstand the hydrostatic pressure. The upper sections can more easily be made buoyant as the hydrostatic pressure is

less at the top. This will help to balance the overall weight of the upper and lower sections.

The tether pipes are dimensioned to carry the tension from a platform consisting  
5 of a nominal pre-tension plus the tension variation by functional and environmental loads. The pipes are kept empty, to reduce the weight/increase buoyancy. The pipes must not only be designed to withstand the loads applied by the platform, but also has to resist the hydrostatic pressure from the surrounding sea. This becomes more prominent as the depth/hydrostatic pressure increases. At  
10 great depths (in the order of 1,000m) the pipes can no longer be designed to have a neutral buoyancy (a diameter to thickness ratio of about 30). In order to withstand the pressure, the diameter to thickness ratio has to be reduced, which results in added load on the platform.

15 The thickness of each section is sized according to capacity. It should also be considered that the tether vertical stiffness is critical for performance, and it is therefore favourable to maintain a fairly equal stiffness/length of each section.

The reduction of overall diameter will typically be made in steps, with intersections  
20 between the steps. The number of steps will depend on the length of the tether/depth of which it is to be used etc.

In-between each diameter, a transition piece carries the load. This is a well proven detail from previous TLP applications.

25 The tethers may have a gradual transition between the upper and lower sections instead of the above described steps, but such tethers are less likely to be used as such tethers probably will require a more complex manufacturing process.

30 With near neutral tethers, the reduction of the hull weight is in the order of 30 percent as compared the hull weight when tethers according to prior art are used. This is due to the decrease of added payload when tethers of the invention are used.

The invention will now be explained in more detail, with reference to the drawings in which

Figure 1 shows a tension leg platform with tethers according to the present invention;

Figure A1 shows the tension distribution of the two concepts;

Figure 2 shows a tether string according to the invention;

Figure 3 shows a cross section of a diameter transition section; and

Figure 4 shows an optimisation chart where a tethers outer diameter and the wall thickness are plotted to show how buoyancy, stiffness and hydrostatic capacity varies.

The following gives an embodiment by way of the following non-limiting example.

A TLP (4) with one step and two tethers (6) having two diameters holding the platform is shown on Fig 1. A transition piece (3) between the diameters is shown on Fig 3 in detail. An upper part of a tether (1) may then have a diameter of 142 mm and a wall thickness of 24.5 mm, whereas the lower part (2) has an outer diameter of 76 mm and a wall thickness of 42 mm. The tethers are anchored to foundations (5).

A tether with two steps is shown on Fig 2.

Samples of further variations in loads, dimensions and configurations are illustrated in Table 1. The embodiments suggests a wellhead platform in West African environment. The deck weight includes the facilities, the structural steel and the operational loads, including the riser tensions. The riser tensions are increased with water depth. The hull and displacement are increased to carry the deck load and the tether pretension.

The thick tether system represents the conventional one thickness tether, which has to have a large thickness to diameter ratio, to withstand the hydrostatic pressure at the bottom. The stepped tether system represents the invention, which allows for reduction of the tether pretension. This allows for reduction of the displacement and of the hull weight.

Table 1 West Africa TLP Application

WATER DEPTH	(m)	1000m	1500m		2000m		3000m		
TETHER SYSTEM	(-)	THICK	THICK	STEPPED	THICK	STEPPED	THICK	STEPPED	MAX. STEP
DECK WEIGHT	(t)	4,800	5,000	5,000	5,300	5,300	5,900	5,900	5,900
RISER TENSION	(t)	2,800	4,200	4,200	5,600	5,600	8,400	8,400	8,400
HULL & BALLAST	(t)	5,300	6,000	5,800	7,100	6,400	10,100	8,200	7,700
TETHER PRETENSION	(t)	2,400	3,300	2,600	5,500	3,000	13,000	6,200	4,500
DISPLACEMENT		15,300	18,500	17,600	23,500	20,300	37,400	28,700	26,500

TETHERS			1	1	2	1	2	1	5	10
NO. OF DIAMETERS										
DIAMETER (top/bott.)	Inch		26	30	46/24	32	52/28	34	56/30	56/30
DIAMETER (top/bott.)	mm		66	76	117/61	81	132/71	86	142/76	142/76
THICKNESS (top/bott)	mm		22.2	28.5	38.5/23	35.5	34.5/31	47.5	24.5/42	24.5/42
MAX. LOAD – TOP	(kN)		7,200	8,900	8,100	12,400	8,000	24,000	14,700	12,600
WEIGHT in WATER	(t)		0	70	-10	300	20	1,100	300	70

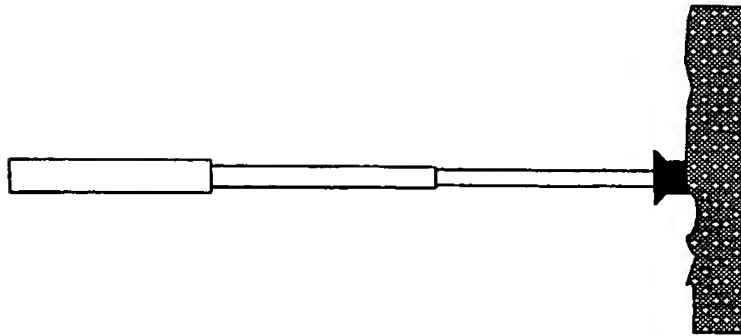
The above described embodiments use steel as the construction material, but the invention is also meant to cover other materials such as composites.

**C l a i m s :**

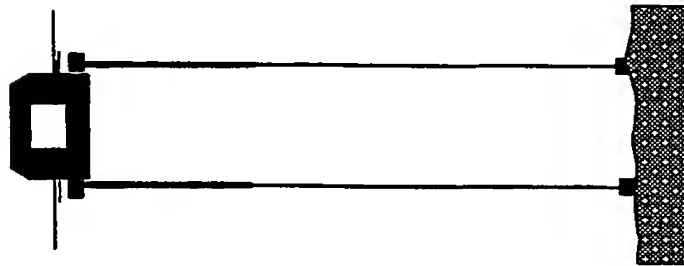
1. Tether system for tension leg platforms (4), with tethers (6) having upper and lower pipe sections (1, 2), characterised by the tethers (6) having a stepped reduction of the diameter towards the seabed such that the upper section(s) (1) have positive buoyancy, and such that the upper section(s) (1) compensate for the weight in water of the lower section(s) (2).  
5
2. Tether system for tension leg platforms (4) according to claim 1, characterised by tethers (6) with an increasing pressure resistance as the depth towards the sea-bed increases.  
10
3. Tether system for tension leg platforms, characterised by tethers (6) having pipes of different diameter, with a substantially continuous reduction towards the seabed, and an increased pressure resistance towards the sea-bed.  
15
4. Tether system for tension leg platforms (4) in accordance with claim 1 or 3, characterised by the tether system having a weight in water close to neutral.  
20
5. Tether system for tension leg platforms (4) according to claim 1, characterised by tethers having pipes with at least two stepped reductions of the diameter towards the seabed.  
25
6. Tether system for tension leg platforms (4) according to claim 1, characterised by tethers having pipes with at least two stepped increases of the wall thickness towards the seabed.
7. Tether system for tension leg platforms (4) in accordance with claim 1 or 3, characterised by having upper sections (1) with reduced wall thickness such that the total cross sectional area of the pipe wall is maintained approximately constant over the height.  
30



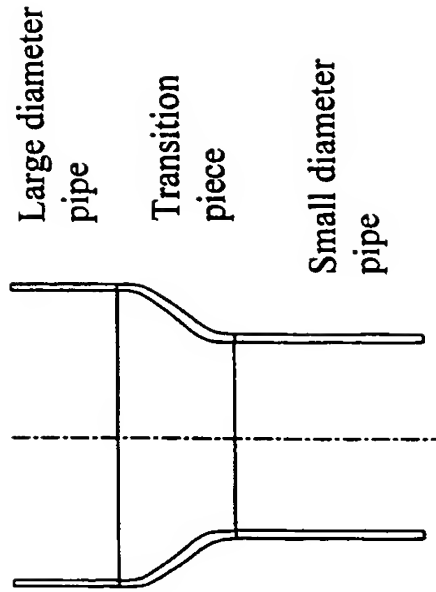
8. Tether system for tension leg platforms (4) in accordance with claim 1 or 3, characterised by having sections made of steel.
- 5 9. Tether system for tension leg platforms (4) in accordance with claim 1 or 3, characterised by having sections made of composite materials.
10. Tethers (6) for deep sea use, characterised by having pipes with a stepped reduction of the diameter towards the seabed.
- 10 11. Tethers (6) for deep sea use according to claim 10, characterised by using the tethers on tension leg platforms
12. Tethers (6) for deep sea use, characterised by
- 15 having decreasing buoyancy towards the seabed



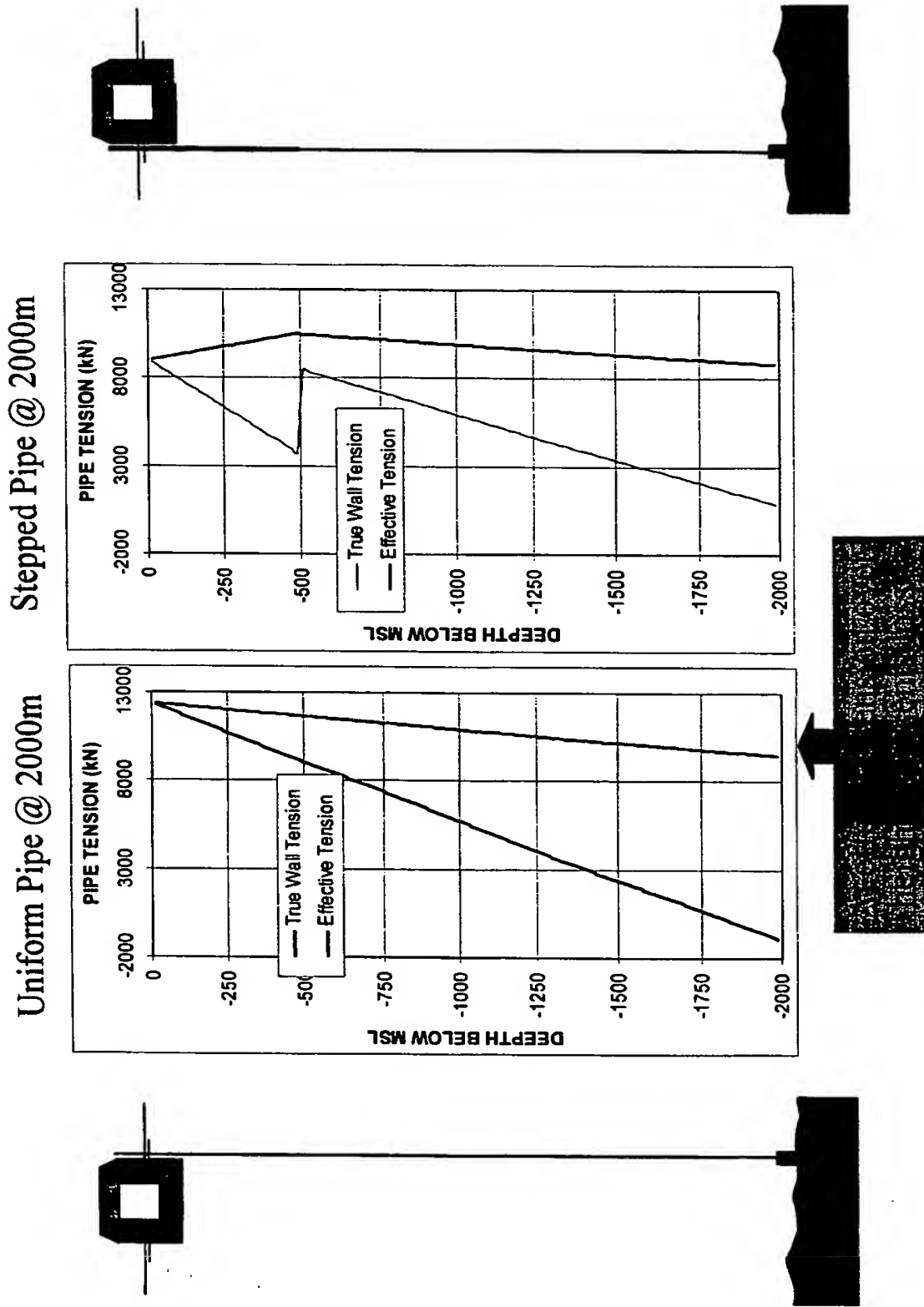
**Figure 2:**  
Tether string



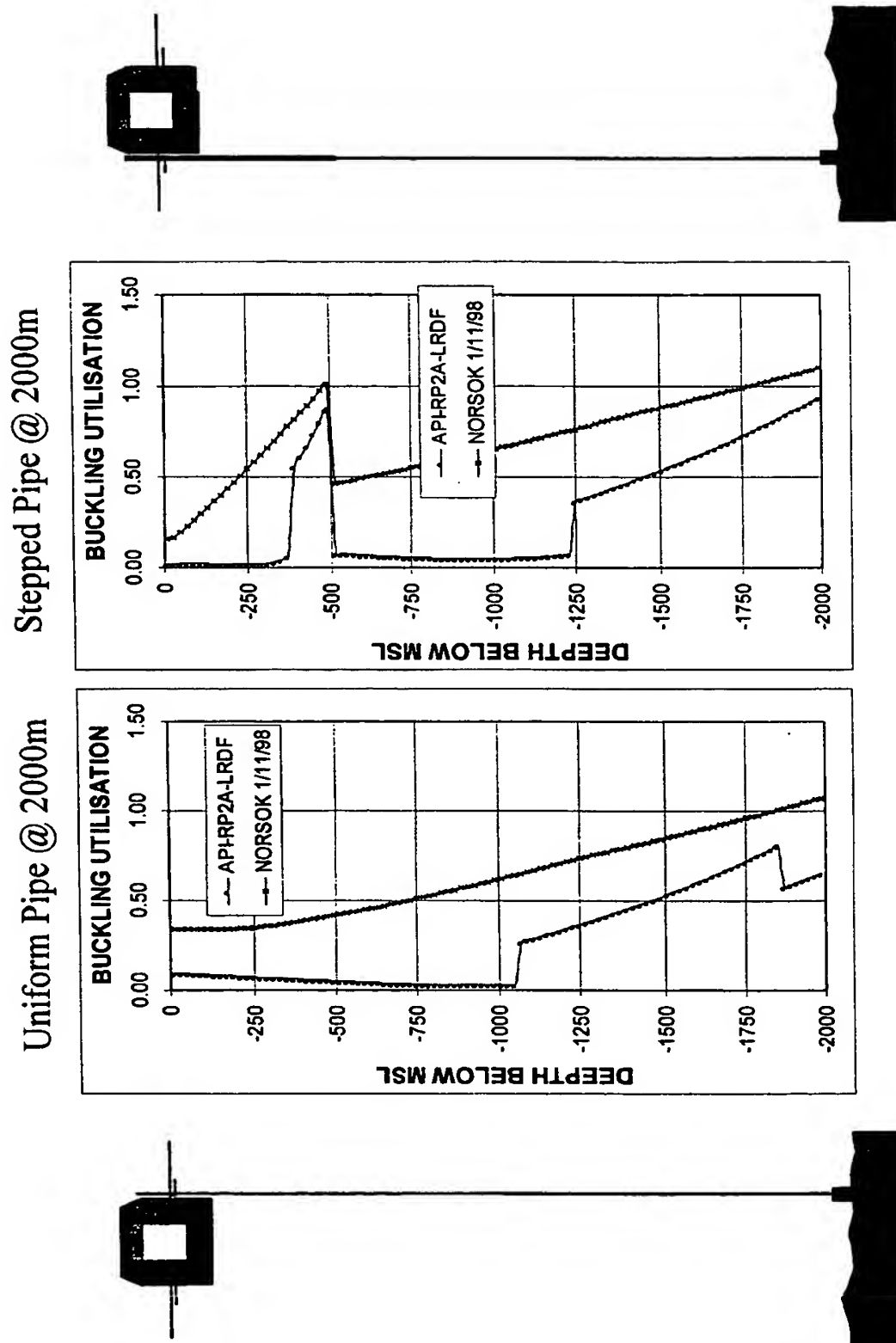
**Figure 1:**  
TLP with tethers



**Figure 3:**  
Diameter transition



**Figure A1 Tether Pipe Tension**



**Figure A2 Tether Pipe Utilization**

### Optimisation

1. Direction of increased buoyancy
2. Direction of increased stiffness
3. Direction of increased hydrostatic capacity

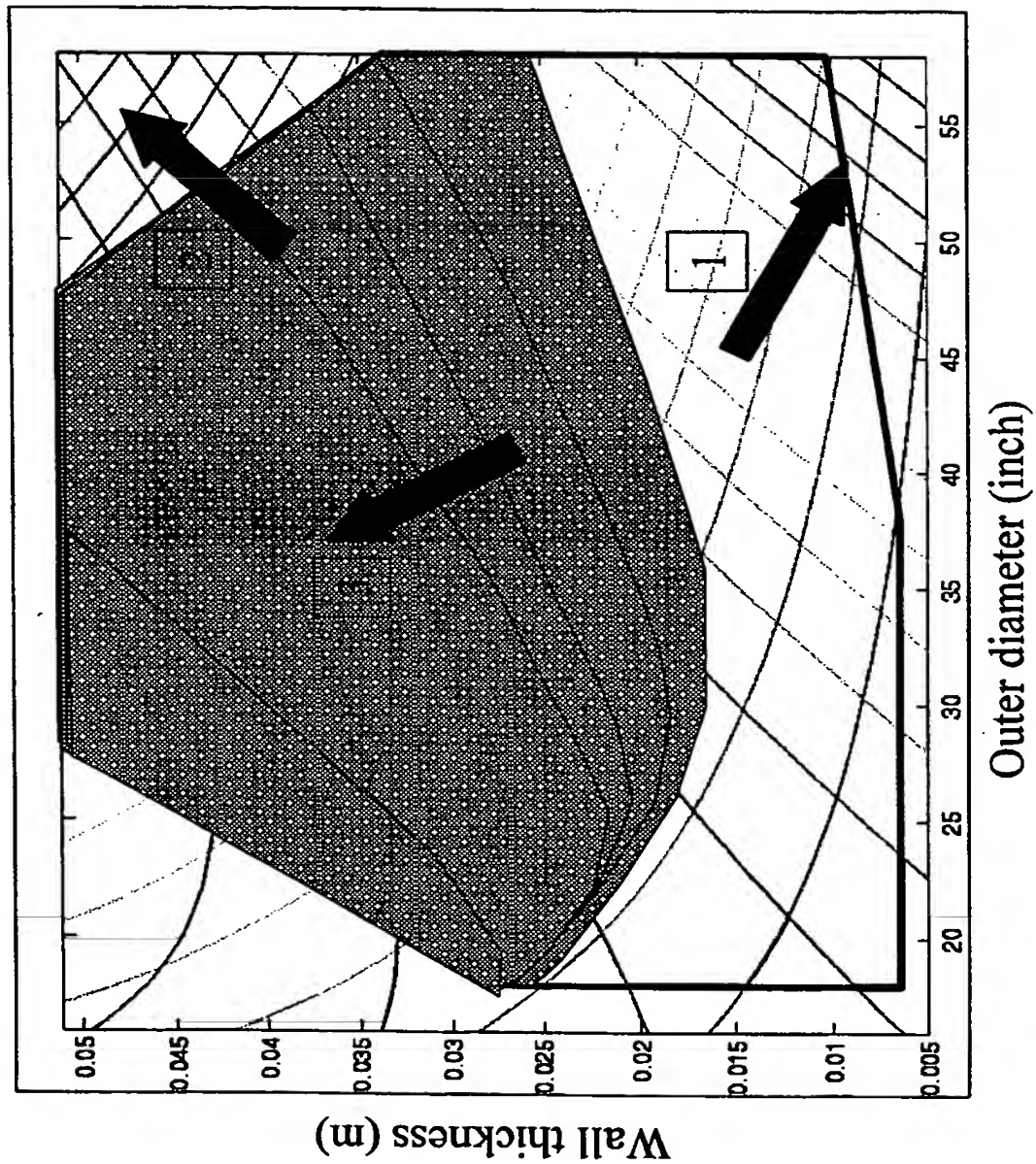


Figure 4: Optimisation chart

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/NO 00/00215

## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: B63B 21/50

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: B63B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5683206 A (COPPLE), 4 November 1997 (04.11.97), column 1, line 48 - column 2, line 29; column 8, line 3 - line 34; column 10, line 26 - line 59, figures 10A,11,12, abstract	1,2,3,4,5,6, 8,10,11,12
A	---	7,9
A	GB 2081659 A (TECNOMARE S.P.A.), 24 February 1982 (24.02.82), page 2, line 6 - line 48, figures 1,2 -----	1-12

☐ Further documents are listed in the continuation of Box C.☒ See patent family annex.

## \* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"I" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&amp;" document member of the same patent family

Date of the actual completion of the international search

17 October 2000

Date of mailing of the international search report

19-10-2000

Name and mailing address of the ISA:

Swedish Patent Office

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**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

03/10/00

International application No.  
PCT/NO 00/00215

Patent document cited in search report			Publication date	Patent family member(s)		Publication date
US	5683206	A	04/11/97	US	5443330 A	22/08/95
				AU	1686292 A	02/11/92
				BR	9205813 A	07/06/94
				EP	0580714 A,B	02/02/94
				NO	307796 B	29/05/00
				NO	933383 A	26/11/93
				US	5118221 A	02/06/92
				WO	9217650 A	15/10/92
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GB	2081659	A	24/02/82	DE	3127978 A,C	25/02/82
				ES	504383 A	01/05/82
				ES	8204497 A	01/08/82
				FR	2486902 A,B	22/01/82
				IE	51255 B	12/11/86
				IT	1131573 B	25/06/86
				IT	8023442 D	00/00/00
				NL	183989 B,C	17/10/88
				NL	8103364 A	01/02/82
				NO	160067 B,C	28/11/88
				NO	812404 A	18/01/82
				US	4482274 A	13/11/84
<hr/>						

REC'D 24 SEP 2001

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PCT

## INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference 102834JH	<b>FOR FURTHER ACTION</b> See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)	
International application No. PCT/NO00/00215	International filing date (day/month/year) 22/06/2000	Priority date (day/month/year) 23/06/1999
International Patent Classification (IPC) or national classification and IPC B63B21/50		
Applicant		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.



2. This REPORT consists of a total of 5 sheets, including this cover sheet.

- ☐ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

These annexes consist of a total of sheets.

3. This report contains indications relating to the following items:

- I ☒ Basis of the report
- II ☐ Priority
- III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
- IV ☐ Lack of unity of invention
- V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
- VI ☐ Certain documents cited
- VII ☒ Certain defects in the international application
- VIII ☒ Certain observations on the international application

Date of submission of the demand  15/01/2001	Date of completion of this report  20.09.2001
Name and mailing address of the international preliminary examining authority:   European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer  Nicol, Y  Telephone No. +49 89 2399 2984 



# INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/NO00/00215

## I. Basis of the report

1. With regard to the **elements** of the international application (*Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17)*):

### Description, pages:

1-5 as originally filed

### Claims, No.:

1-12 as originally filed

### Drawings, sheets:

1/4-4/4 as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

These elements were available or furnished to this Authority in the following language: , which is:

- ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
- ☐ the language of publication of the international application (under Rule 48.3(b)).
- ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

- ☐ contained in the international application in written form.
- ☐ filed together with the international application in computer readable form.
- ☐ furnished subsequently to this Authority in written form.
- ☐ furnished subsequently to this Authority in computer readable form.
- ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
- ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

- ☐ the description, pages:
- ☐ the claims, Nos.:

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT**

International application No. PCT/NO00/00215

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

*(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)*

6. Additional observations, if necessary:

**V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement**

1. Statement

Novelty (N)	Yes:	Claims	1-12
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-12
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-12
	No:	Claims	

2. Citations and explanations  
**see separate sheet**

**VII. Certain defects in the international application**

The following defects in the form or contents of the international application have been noted:  
**see separate sheet**

**VIII. Certain observations on the international application**

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:  
**see separate sheet**

**INTERNATIONAL PRELIMINARY  
EXAMINATION REPORT - SEPARATE SHEET**

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International application No. PCT/NO00/00215

**1. POINT V**

Reference is made to the following documents:

D1: GB 2081569 A

D2: US 5 683 206 A

The constructional element in D2 has features similar to those described in the present application in that both include cylindrical elements with a change of the diameter used in connection with the positioning of offshore installations. However, the application is explicitly claiming a tether for tension leg platforms, whereas the document D2 describes a carrying system for supporting a construction columns. In D2, the function, construction and field of use is therefore different as in the present application. Document D2 is therefore not relevant in the appreciation of the novelty of the application.

Document **D1**, which is considered to represent the most relevant state of the art from the search report, discloses a tether system (wordingly a floating platform mooring system) according to the preamble of claim 1.

The **problem** to be solved by the present application is to design a simple and reliable construction of a tether system for tension leg platforms whereby the overall buoyancy of the tension legs is meant to be neutral.

The **solution** proposed by the application consists in *tethers having a stepped reduction of the diameter towards the seabed* as claimed in the characterising part of independent claims 1, 3, 10 and 12.

This combination of features of independent claims 1, 3, 10 and 12 is neither known from, nor rendered obvious by, the available prior art cited in the international search report.

As claims 2, 4-9, 11 are dependent on one of the independent claims 1, 3 and 10, their subject-matter are therefore also novel and inventive.

The subject-matter according to any of claims 1 to 12 is industrially applicable.

## **2. POINT VII**

3.1 The drawings are not provided with reference signs although there are reference signs mentioned in the description and in the claims (Rule 11.13 I),m) PCT).

3.2 The figure A2 is not mentioned in the description (Rule 5.1)

3.3 To meet the requirements of Rule 5.1 PCT, the document D1 should be identified in the description and its relevant contents should be indicated. The applicant should ensure that it is clear from the description which features of the subject-matter of the claims is known from this document. The problem solved by the present application should be clearly identified.

## **3. POINT VIII: conciseness and clarity**

Although claims 1, 3, 10 and 12 have been drafted as separate independent claims, they appear to relate to the same subject-matter and to differ from each other only with regard to the definition of the subject-matter for which protection is sought or in respect of the terminology used for the features of that subject-matter. The aforementioned claims therefore lack conciseness. Moreover, lack of clarity of the claims as a whole arises, since the plurality of independent claims makes it difficult, if not impossible, to determine the matter for which protection is sought, and places an undue burden on others seeking to establish the extent of the protection.

Hence, claims 1, 3, 10 and 12 do not meet the requirements of Article 6 PCT.

In addition, claims 1 and 3 are not clear and not consistent because the problem solved by the features of these claims seems to be different:

in claim 1, the problem is the compensation of the weight in water of the lower sections of the tethers by the upper sections, although in claim 3 the problem is to increase the pressure resistance towards the seabed.